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AIR LIFT PUMPS¹

BY CHAS. J. DEEM²

It has been charged by some that the manufacturer of air lift pumps wishes to surround his product with mystery. This is not the case. The manufacturers of air lift pumps, like any other trades-people, wish to sell all of their product that they can and will give all the information regarding its operation that will make it more popular in the deep well pumping field. However, they are limited in this desire by the fact that no master formula has as yet been devised whereby infallible rules can be laid down for the proper design and installation of any and all lifts without any regard for the conditions that exist in the wells.

Some fifteen years of experience has taught the author that in many instances wells are just as individual in their actions as are persons. Therefore, a properly designed air lift installation, operating satisfactorily in one well, might give entirely different results when installed in another well which, to an inexperienced operator, might seem to be identical. While experience is not absolutely essential to the pumping of water from deep wells by means of compressed air, yet the author knows of no engineering field where experience counts for more than in air lift pumping.

Contrary to popular belief, the compressed air discharged through an air lift pump does not blow the column of water upward after the first discharge. When the static head is lifted from the working head of the well by the first inrush of air, the water is forced out of the pipe in a solid column. After that, the compressed air passing through the pump reduces the specific gravity of the water in the discharge line of the pump. This consequently moves upward by the expansion of the air bubbles, aided by the greater weight of the solid column of water surrounding the discharge line.

¹Read before the Iowa Section, October 23, 1919.

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In an economically designed air pump, it is imperative that the formation of large bubbles of air be avoided, for these have a tendency to rush upward without lifting the proper amount of water for the stored energy that they contain. Therefore, the pump should divide the air into small streams or jets, creating as many small bubbles as possible in order to give the best economy. The slip of these bubbles constitutes the chief loss in the energy of the air lift. It is figured that this varies as the square root of the volume of the bubbles. Therefore, the smaller the bubbles, the more efficient the air lift.

One of the foremost things to be considered in installing a pumping plant is its efficiency. Probably there is no one word in the English language that is used more today in manufacturing and engineering circles than "efficiency." The only true way the author knows to figure the efficiency of a pumping plant is that at the end of the year the column in the ledger headed "operating costs" be added up and the results calculated from its total. In this column there will be found items such as repairs, break-downs, and their attendant losses, and it is possible to read between the lines the worry that was caused thereby.

To give some idea of the faith that the underwriters of the country have in the reliability of the air lift system, the author desires to point out, with Mr. Judd's permission, that by discarding deep well pumps and installing air lift systems in the city wells in Mason City, the Board of Underwriters in Chicago granted 30 points on the key rate of insurance for the fire protection which the increased yield of the well would afford the city, and they gave 130 points because of the reliability of an air lift pumping system.

Some years ago the author installed an air lift in a flowing well on a ranch in southwestern Texas. The well was 8 inches in diameter, about 600 feet deep and flowed about 20 gallons a minute. The owner of the ranch had only a small compressor, its maximum capacity being 30 cubic feet of compressed air per minute. A 6-inch pump was installed, and these 30 feet of air delivered to it. The head of the well dropped 20 feet from the surface and the well yielded 530 gallons per minute, accurately measured over a knife-edged weir. Of course, this was phenomenal. Never before or since has the author seen such a small volume of air deliver so much water from a deep well.

A few weeks ago, at Fort Dodge, Iowa, a 6-inch pump was installed in a flowing well on an island in the Des Moines river. The well was 8 inches in diameter, 500 feet deep and flowed 21 gallons per minute. The same size pump was located 200 feet from the surface and 200 cubic feet of air were delivered to it. The working head of the well dropped 150 feet from the surface and yielded 80 gallons per minute. This proved to be a very uneconomical installation. Yet to all outward appearances, the conditions in the second well were the same as those in the first mentioned. In this second well experience would have been necessary to have properly readjusted the piping, had the city decided to use it. However, there was plenty of other water available, so the well was abandoned. But an air lift could have been installed in it, which figuring from the current input at the motor of the compressor to the water discharged in the reservoir, would have shown 30 per cent efficiency. This could have been obtained by installing a 3-inch air lift and taking 50 per cent submergence, or, in other words by placing the lift as far below the working head of the well as it was desired to lift the water. This would have yielded 1 gallon of water for 0.63 cubic foot of air at 67 pounds pressure. Of course, the starting pressure in this well would have been greater than that of the other wells of the system, yet this would have been offset by the use of an auxiliary air line to lift the head off the well. Had the original installation in this well been let stand, any one wishing to speak disparagingly of air lift pumping could have, in all honesty, cited it as an expensive mode of pumping water. On the other hand, some manufacturer, wishing to extol the virtues of his pumps, might honestly print a glowing advertisement of the results obtained in the well first described. Both would be equally misleading.

It has been stated that an air lift system requires little or no attention outside of keeping the compressor in proper running order. While this is practically true, yet there are times when the system becomes unbalanced and the working head of the wells recedes, which changes the percentage of submergence, thereby reducing the yield of the well and increasing the amount of air required. If conditions at the wells are checked up once or twice a year, and changes made to meet the new conditions, a great deal might be saved in operating cost at times. Not so long ago the author was called to a plant where a battery of five wells was pumped from one compressor. The compressor at its maximum speed was barely

large enough to pump the amount of water required. The operator said that when the plant was first installed it gave excellent results, but there had been a decided falling off in the yield of the wells. The system had not been installed by the company the author represents, but it was well designed and should have given good results. Upon investigation, it was found that two of the wells were much weaker than the other three, and that they operated at about 15 pounds less pressure than the other wells. When the engineer had balanced up the system, he had set the regulating valve at the well heads of these two weaker wells so as to admit only enough air to pump the water that they would economically yield, and, of course, had left the valves wider open on the strong well. When starting the system, the operator discovered that many times these two weak wells did not come in. In order to overcome this he had opened the valves of these weaker wells. Any force follows the line of least resistance and the larger part of the volume of air from the compressor rushed into the weaker wells where it could not lift the amount of water that it could have done in the stronger wells. Therefore, this system was out of balance and giving poor results, through no fault of the air lift or the man who installed it.

A great many mistakes are made, when installing air lifts, in reference to the size of the pump to be used to deliver a certain volume of water. For instance, if it is desired to lift 150 gallons per minute from a well with a working head 80 feet below the surface, the most economical pump to be installed here would be a $3\frac{1}{2}$ -inch lift at 65 per cent submergence. Under these conditions, this pump should yield 1 gallon of water for every 0.3 cubic foot of air at 67 pounds pressure. The pump would be located 229 feet from the surface. Now suppose, instead of being able to get 65 per cent submergence, it is possible to get only 40 per cent submergence. In order to deliver 150 gallons per minute under these conditions, a $4\frac{1}{2}$ -inch pump should be used and we may expect a gallon of water for every 0.59 cubic foot of air at 25 pounds pressure. It will require 1.1 more horse power to raise the water in the second instance than in the first. As the submergence decreases, the size of the discharge line should increase. But this is only a general rule and the conditions in the well to be pumped wholly govern the ratio of the change to be made.

Of late years some engineers have been advocating a variable discharge line. They wish to start with a smaller pipe and expand

toward the point of discharge, the theory being that by allowing the compressed air more space in which to expand, it will lend more of its energy toward lifting water. On the other hand some engineers advocate turning this type of installation upside down, as it were; that is, they reduce the diameter of the line toward the point of discharge, the theory being the same as the reason for choking the muzzle of a rifle in order to keep all the gases behind the bullet until it leaves the barrel. Of the two systems, so far as observation has gone, the latter is to be more preferred. The author has seen it produce excellent results under some conditions, that is, by furnishing more water with greater economy than would be possible with a uniform discharge line made of standard pipe sizes. Probably the friends of the expanded discharge line system will challenge this statement and point to some installations they claim are great successes. The author has seen one or two of these but they have been invariably installed in excellent wells that yielded large quantities of water very economically, not because of the system of expanding the discharge line, but in spite of it.

Another improvement in the air lift system that should be mentioned briefly is what is known as the booster pump. This is a tank located on the well top. It automatically separates the air and water as they are discharged from the well, and retains just enough pressure from the separated air to force the water to the point of discharge. This is a great improvement when the water must be transferred long horizontal distances toward the point of discharge. Hitherto when horizontal distances had to be considered, unless the water was delivered to an elevated tank and allowed to flow from it by gravity, the air would get ahead of the water in the discharge line, thereby materially reducing the efficiency of the system.